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REPRODUCTIVE SUCCESS AND CAUSES OF NEST FAILURES FOR MISSISSIPPI KITES: A SINK POPULATION IN EASTERN ARKANSAS?

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Abstract: In the White River National Wildlife Refuge, we located and monitored 39 Mississippi Kite (*Ictinia mississippiensis*) nests during the 2004 and 2005 breeding seasons to examine reproductive success and causes of nesting failures. Nest failures were documented using five video recording systems. All kite nests not monitored with a video recording system were observed every 3 or 4 d. The apparent reproductive success during this study was 28.2% (n = 39 nests). Using the Mayfield estimator, we determined the nest success to be 36.3% over 1226 nest-exposure days with a daily nest survival of 0.9837. We recorded seven nest failures and eight probable predation attempts. Predation was the most common cause of nest failures of video observed nests (57%), with western rat snakes (*Elaphe obsoleta*) being the most common predator of kite eggs and nestlings. Other observed nest failures included nest abandonment, a chick falling out of a nest, and an infertile egg. Reproductive success reported in this study was the second lowest (28%) of all Mississippi Kite studies. This low reproductive success rate is likely not adequate to support a viable population in the White River National Wildlife Refuge, indicating this may currently be a sink population.

Key Words: bottomland hardwood forest, hydrology, *Ictinia mississippiensis*, predation, video-recording system

INTRODUCTION

The Mississippi Kite (*Ictinia mississippiensis*) is a small raptor that inhabits numerous habitats throughout the United States including urban settings and remote bottomland hardwood forests. This species occurs in two more-or-less distinct populations. The Great Plains population consists of kites in select areas of the central and southern Great Plains, including parts of Colorado, Nebraska, Kansas, Oklahoma, Texas Arizona, and New Mexico. The eastern population extends from the Mississippi River eastward to the Atlantic Coast. In western populations, kites characteristically nest in colonies often in riparian areas and shelterbelts as well as in urban golf courses, parks, and neighborhoods (Parker 1988). The eastern population typically inhabits lowlands, riparian, and bottomland hardwood forest (Evans 1981, Whitmar 1987), but nesting kites have also been reported in urban areas (Parker 1999). Both populations have suffered a decline in numbers in the late 1800s and early to mid 1900s. The eastern population has probably declined more so than the western population because the influence of humans was much greater during this time period in the eastern U.S. (Parker 1999). Several factors were associated with this population decline, including egg collecting, shooting, habitat loss, and habitat fragmentation (Parker and Ogden 1979).

Habitat loss and fragmentation are probably most significant causes of Mississippi Kite decline (Parker and Ogden 1979, Bolen and Flores 1989) and continue to affect the population today. Gosselink and Lee (1989) estimated that at the time of European settlement, there was approximately 80 million ha of forested freshwater wetlands in the United States, with the majority of them occurring in the Mississippi Alluvial Valley (MAV). As these forests were cut, the Mississippi Kite showed a decrease in numbers. Baerg (1951) considered it rare in Arkansas and this kite was almost nonexistent in the central Mississippi Valley between 1910 and the early 1950s (Parker and Ogden 1979). During this period emphasis on agriculture production overwhelmed interest in habitat protection and the loss of the forested wetlands continued at an alarming rate. By the 1970s, the areas covered by forested wetlands were less than 25 million ha (Gosselink and Lee 1989) and bottomland hardwood forest only

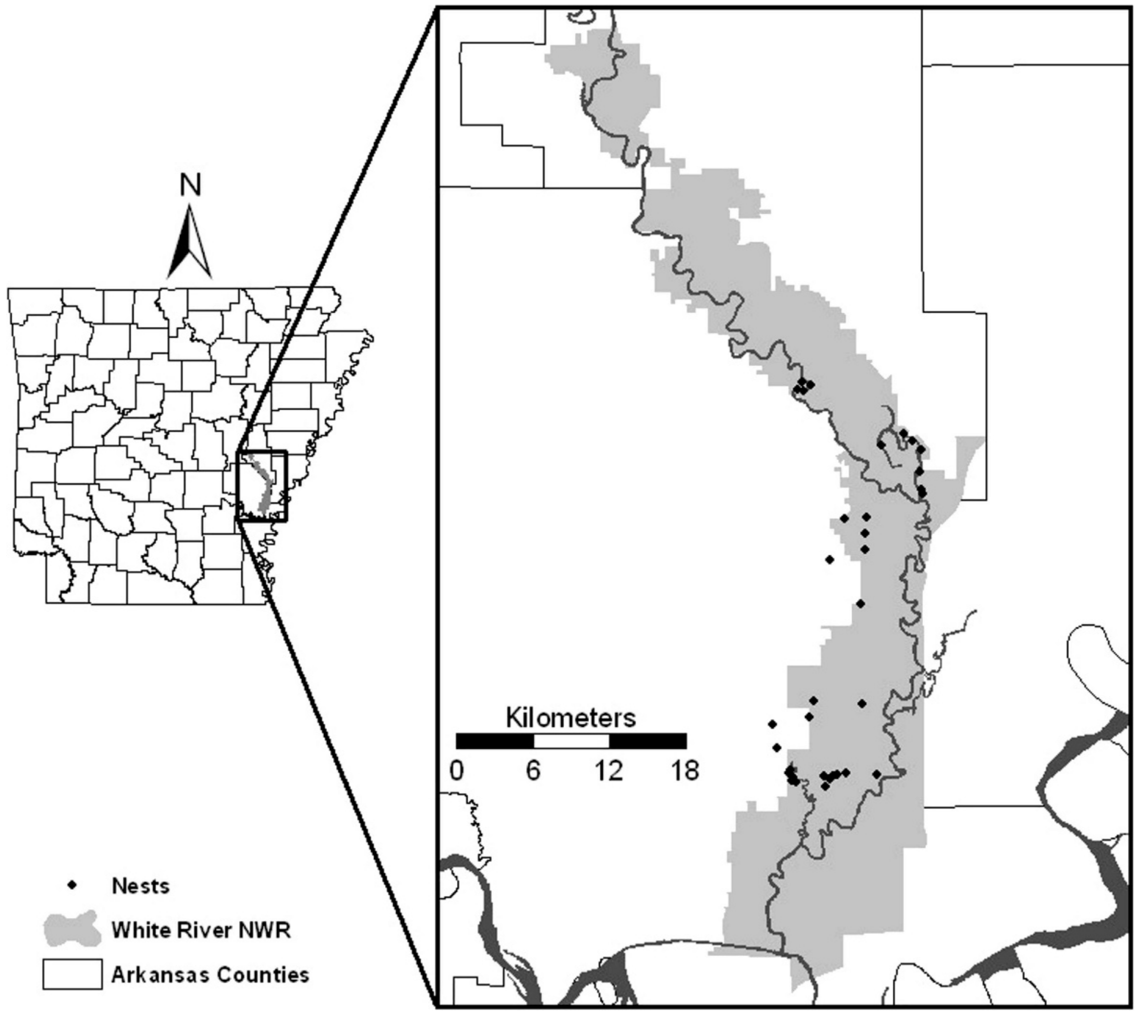

Figure 1. Locations of 39 Mississippi Kite nests in the White River National Wildlife Refuge (NWR) and vicinity in Arkansas monitored in 2004 and 2005.

comprised about 2.1 million ha of these wetlands (Gosselink et al. 1990).

In spite of the continuation of habitat loss, the population of Mississippi Kites seemed to rebound in the 1950s, with several accounts of local increases and reoccupation of its range (Parker and Odgen 1979) including the first reported re-sightings in Arkansas County, Arkansas (Meanley and Neff 1953). In the Great Plains, kites probably benefited from an increase of prey caused by widespread irrigation and overgrazing (Parker and Ogden 1979). Shelterbelt plantings in the late 1930s by the Civilian Conservation Corps throughout the Great Plains probably also benefited the kite population by providing nesting habitat (Parker 1988). Even though the Mississippi Kite population has appeared to partially recover and has been suggested to benefit from some aspects of fragmentation (Glinski and Ohmart 1983), it still faces many obstacles related to its long-term conservation.

Studies throughout the western U.S. have documented success of nests ranging from 49–84% (Parker 1974, 1975, 1999, Glinski and Ohmart 1983, Shaw 1985, Gennaro 1988). Studies in Illinois (Evans 1981) and in Missouri (Barber et al. 1998) have reported reproductive success rates of 61% and 42%, respectively. A recent study conducted in the White River National Wildlife Refuge (WRNWR) from 2001 to 2003 documented a reproductive success of only 18% (St. Pierre 2006). This low reproductive success suggests a struggling and nonviable population in the MAV of central Arkansas. Here, we further investigate the reproductive success and causes of nest failure of Mississippi Kites on the WRNWR.

STUDY AREA

The WRNWR (Figure 1) is located in Arkansas, Desha, Monroe, and Phillips counties of southeastern Arkansas. The WRNWR is approximately 62,800 ha in size and is divided into two units by Arkansas Highway 1. The South Unit of WRNWR, where the majority of our work was conducted, is the larger of the two units (ca. 41,440 ha). This unit extends from St. Charles, Arkansas south to the confluence of the White River and the Arkansas River Canal (Figure 1).

The WRNWR consists mostly of bottomland hardwood forest, with some upland forest, fallow fields, agricultural fields, moist-soil impoundments, and 356 natural and man-made lakes. The refuge is open to the public for recreational use, hunting, and fishing and is managed for both game and non-game wildlife species. For over 50 yr, forest management practices have focused on selective cutting to create suitable habitat for wildlife. Dominant tree species of WRNWR include Nuttall oak (*Quercus nuttallii*), overcup oak (*Q. lyrata*), baldcypress (*Taxodium distichum*), sugarberry (*Celtis laevigata*), hickory species (*Carya* spp.), and green ash (*Fraxinus pennsylvanica*). Tree taxonomy follows Moore (1991).

METHODS

Nest Searching

We initiated nest searching for Mississippi Kites on 9 and 23 April 2004 and 2005, respectively. We conducted searches with an outboard motorboat, all-terrain vehicle (ATV), kayak, or on foot. Our primary search areas were locations of previous sightings within the refuge (St. Pierre 2006), but we also surveyed additional areas throughout the refuge. Areas searched included: 12 bayous (126 km), 19 lakes, and over 64 km of the White River throughout the South Unit and portions of the North Unit of the WRNWR. We traveled by boat along the waterways, starting at about sunrise and looked for kites perched in trees along the waters' edge. Mississippi Kites frequently perch in trees along waterways near their nests (St. Pierre 2006). Once a Mississippi Kite was located, it was observed for possible breeding behaviors such as carrying sticks or copulation. When these activities were observed, we used binoculars to follow the kite until it went to a nest or a suspect super-emergent tree that could support a nest. If a kite was observed landing in a tree, we examined that tree using binoculars until the nest was located or until we concluded that no nest was there. Nest searching for Mississippi Kites was continued until a nest was found for all located pairs or until the kites abandoned the area.

Nest Monitoring

We monitored Mississippi Kite nests and classified sites as occupied if an adult kite was observed at the nest on more than one occasion. Nests that were built, but not documented to contain eggs were included in the apparent reproductive success calculation (Steenhof and Newton 2007). The Mayfield estimator was also used to calculate reproductive success (Mayfield 1975). Nests were monitored every 3–4 d with a spotting scope or binoculars, from a distance of approximately 50–100 m to minimize disturbance at the nest. We observed a nest until some type of activity was recorded (e.g., exchange of incubating adults or prey delivery). If no activity was observed within 1 hr, at least three more observations were made at later dates before classifying the nest as failed. Observations of adult activities at nests were used to determine the stage of the nest and to estimate the dates of hatching and fledging.

Video Recording of Kite Nests

We used three high-resolution infrared video recording systems (Fieldcam: Field Television System: LDTLV/Box/Versacam/IR60, Fuhrman Diversified Inc., Seabrook, TX, USA) to monitor nests. These systems were designed for use in the field 24 hr a day. The recording systems consisted of a Sony VHS time-lapse recorder (SVT-LC300, New York, NY, USA) and the camera was a Sony Color Ultra-High Resolution Versacam (Versacam, New York, NY, USA) with infrared capabilities up to 23 m away. This camera system was equipped with an 18× optical zoom and a 4× digital zoom so it could be adjusted for a tight or wide view of the nest. We also used two Supercircuits color mono-power infrared video cameras (PC177IR-1color, Liberty Hill, TX, USA) and two Supercircuits VHS time-lapse recorders (NCL3300, Liberty Hill, TX, USA) to monitor kite nests. We placed each video camera at a separate Mississippi Kite nest that had incubated for at least 7 d. We did not disturb nests during the first 7 d after laying to reduce any chance of the kites abandoning their nest due to the setup of video cameras. Nest trees that had little or no adjacent mid-story were selected first for placement of the Fuhrman camera systems. The placement of this camera system in an adjacent tree further minimized the disturbance to adult kites. If possible, the camera was placed at the same height as the nest or higher than the nest to allow for a complete view of the activities that took place in the nest. The Supercircuits camera systems were placed in the nest tree approximately 40 cm above the nest.

Cameras were left at each nest until the young fledged or the nest failed. The systems used VHS tapes and recorded 8 frames per sec, allowing a single T-160 video tape to last for 72 hr. We connected two or three deep-cycle batteries to each camera system, which provided enough power to run each system for 3 d. Every third day, we changed batteries, replaced the video tape, and viewed the monitor to ensure the camera remained focused. Once the nest failed or the young fledged, then the camera system was removed and mounted at another occupied nest. The video tapes with recorded data were viewed through a television using a Sony time lapse videocassette recorder (SVT-RA168, New York, NY, USA).

RESULTS

Nest Searching

Between mid-April and 1 July, 39 Mississippi Kite nests were located (21 in 2004 and 18 in 2005). Of those, 35 were in the South Unit from Indian Bay south to Brooks Bayou and four were located in the North Unit. Thirty-one of the Mississippi Kite nests found were located on bayous, four nests were located on lakes, and four were located along the White River.

Reproductive Success

Eight of the 39 nests were abandoned during or shortly after the nest-building stage and likely before the egg-laying stage. Thirteen nests failed during incubation: two of these failures were documented by video cameras, egg shells were found beneath three nests, and eight nests had no visible sign of predation or other evidence that would suggest the cause of nest failure. One of the nests where egg shells were found was no longer in a recognizable condition. In this case, because there were no strong wind events in this area during the days prior to the destruction of this nest, we believe that the nest was likely destroyed by a relatively large mammal. The remaining two nests where egg shells were found showed no sign of disturbance. Eighteen of the 39 (46.2%) Mississippi Kite nests hatched young successfully. Of these, only one nest hatched more than one young (two young). Seven of the 18 nests that hatched young successfully failed before they fledged; five of these nest failures were documented by video cameras. The remaining two nests failed due to unknown causes. Eleven nests fledged one chick each, resulting in an apparent reproductive success (Steenhof and Newton 2007) of 28.2% (n = 39). If nests where egg-laying did not occur were excluded from the reproductive success calculation, the apparent nest success estimate was 35.5 % (n = 31). Based on the Mayfield (1975) estimator, nest success was 36.3% (assuming 30 day incubation and 33 day brood-rearing periods) over 1226 nest-exposure days with a daily nest survival of 0.9837 (n = 31). Nest productivity, defined as the mean number of fledglings per successful nest, for both years was 1.0 (n = 11). Four successful and one unsuccessful Mississippi Kite nests built in 2004 were reused in 2005. Of these five reused nests, three of them were successful in 2005.

Video Recording of Kite Nests

We collected video data at 16 (7 nests - 2004, 9 nests - 2005) Mississippi Kite nests using three camera systems during the 2004 field season and 5 camera systems during the 2005 field season. During both field seasons (late May to mid to late August), 401 d of data were recorded (mean = 25 d/nest; range = 3–58 d). Review of videos documented seven nest failures and eight predation attempts that did not result in failure (Table 1).

At nest 04-13 (Table 1), an eastern gray squirrel (*Sciurus carolinensis*) climbed into a Mississippi Kite nest on 16 June 2004, while the adult female was incubating eggs. The squirrel left a few seconds later after the adult kite physically attacked the intruder. Then on 22 June 2004, a small *Buteo* identified as either a Red-shouldered Hawk (*Buteo lineatus*) or a Broad-winged Hawk (*Buteo platypterus*), attacked an adult sitting on the nest with nestlings. The *Buteo* hit the kite on the back with its feet, then left without disturbing the nestlings. Both of these failed predation attempts were at the same nest. This same nest was then depredated on 25 June 2004 by a Barred Owl (*Strix varia*), which left with a nestling in its bill at 1119 H.

Nest 04-16 (Table 1) failed when a nestling fell out on 10 August 2004. Most of the nest structure had fallen 2 d prior and the nestling was standing on a few remnant sticks in a fork of the tree. At 0111 H, the adult female was brooding the nestling when it appeared she tried to sit on the nestling and pushed it out of the remnant nest. The nestling caught itself on a limb and made several attempts to jump back into the "nest," but could not return because the adult blocked the way. After 2 hr of struggling, the nestling fell out of the view of the camera.

At nest 05-3 (Table 1), the adult Mississippi Kites had been incubating a single egg for approximately 30 d, when the egg was observed to have a small hole in it on the 24 June 2005. Three days later, the

Table 1. Activities and nest failures documented with video cameras at Mississippi Kite nests in the White River National Wildlife Refuge, 2004–2005.

Nest ID	Dates Monitored (Days)	Video Camera[1]	No. Eggs/Chicks	Stages Monitored	Key Events	Nest Outcome	Cause of Nest Failure
04-13	4–28 June 2004 (24)	Fuhrman	1	Incubation	16 June – squirrel attack 17 June – hatched	Failed	Barred Owl predation
				Nestling	22 June – hawk (unid) attack 25 June – Barred Owl predation		
04-16	19 July–12 August 2004 (24)	Overhead	1	Nestling	10 August – chick falls out of nest	Failed	Chick fell out of nest
04-12	17 June–12 July 2004 (25)	Fuhrman	2	Nestling	28 June – siblicide	Fledged 1 chick	Successful
05-5[2]	2 June–30 July 2005 (58)	Overhead	1	Incubation	4 June – Red-tailed Hawk (adult) & Cooper's Hawk (juv.) landed on nest 6 June – Cooper's Hawk (adult) attack 9 June – Red-shouldered Hawk (adult) attack	Fledged	Successful
				Nestling	22 June – egg hatches 28 July – chick fledges and afterwards Red-shouldered Hawk (juv.) lands on nest		
05-3	22–29 June 2005 (7)	Overhead	1	Incubation	24 June – egg has small hole 27 June – adult male picks egg apart	Failed	
05-8	6 June–11 July 2005 (35)	Overhead	1	Incubation	28 June – rat snake enters nest & ejected by female 9 July – rat snake consumes egg	Failed	Western rat snake
05-1	2–30 June 2005 (28)	Fuhrman	1	Incubation		Failed	Western rat snake
				Nestling	18 June – chick hatches 29 June – rat snake consumes chick		
05-11	7–26 July 2005 (19)	Overhead	1	Nestling	25 July – rat snake consumes chick	Failed	Western rat snake
05-9	5–11 July 2005 (6)	Fuhrman	1	Nestling	6 July – adult female left nest & never returned	Failed	Abandoned

[1] Fuhrman camera system – Fuhrman Diversified Inc., Seabrook, TX, USA; Overhead camera system – Supercircuits, Liberty Hill, TX, USA.
[2] Same nest as 04-13.

male kite broke the egg apart by pecking at it with his bill.

Western rat snakes depredated three kite nests. At nest 05-8 (Table 1) on 28 June 2005, a female pulled a rat snake out of the nest. In the same nest, on 9 July 2005 at 2134 H, a western rat snake flushed the male kite and consumed the egg. Nest 05-1 (Table 1) contained an 11-d-old nestling when a western rat snake crawled into the nest on 29 June 2005 at 2200 H, the female kite attacked the snake, then left the nest. She returned at 2229 H, but was again attacked by the snake and left the nest. The snake then consumed the nestling. Nest 05-11 (Table 1) contained a 4–5 wk-old nestling, when on 25 July 2005 at 2059 H, a rat snake approached the nest and the female kite attacked. The rat snake then struck the adult kite on the head, after which the kite left the nest. Then, the snake consumed the nestling.

The final nest failure documented by video occurred on 7 July 2005 at nest 05-9 (Table 1) with one nestling. The female kite returned to the nest 35 min after camera setup (1215 H: 5 July) and remained until 1131 H on 6 July 2005, after which a kite was documented flying by the nest on two occasions later that day, but no kite returned to tend to the nest. The nestling was last observed alive at 1819 H on 7 July 2005.

A siblicide event was also documented by a video camera in 2004 (nest 04-12; Table 1). At 1400 H, on 28 June 2004, a nestling approximately 3-wk-old began pecking the head of its smaller sibling. The older nestling pecked the head and body of the smaller nestling several times when the adult female was present. At 1419 H, the small nestling was lifeless and all the feathers were pecked off its head. At this time, the surviving nestling began to eat the dead nestling and on several occasions was fed parts of the dead nestling by the adult female. Review of the prey delivery data from this nest showed a decrease in prey deliveries both the day of and the day before the siblicide event. The mean number of prey deliveries for the week before the siblicide was 24 and 30 prey items per day by the female and male, respectively. The mean number of prey deliveries for the day of the siblicide and the day prior was 16 and 14 by the female and male, respectively.

At nest 05-5 (Table 1), we recorded five hawks visiting the nest during the 58-d monitoring period. This nest was the same nest that was depredated by a Barred Owl in 2004. On 4 June 2005, the male was incubating a single egg, then at 1043 H the male left and an adult Red-tailed Hawk (*Buteo jamaicensis*) landed on the edge of the nest. The hawk stayed for about 1 min then left, not harming the egg. Later that day (1259 H) the female kite was incubating the egg when she suddenly left and seconds later a juvenile Cooper's Hawk (*Accipiter cooperii*) landed on the edge of the nest. The egg was not harmed and the hawk left after about 1 min. On 6 June 2005, the female kite was incubating when an adult Cooper's Hawk attacked her, but the kite defended the nest. On 9 June 2005 at 1857 H, an adult Red-shouldered Hawk landed beside the nest and again the female kite defended the nest. The nestling fledged on 28 July after which a juvenile Red-shouldered Hawk landed on the nest (Table 1).

DISCUSSION

Currently, the Mississippi Kite has an estimated population of 190,000 in the United States and is classified by Partners in Flight as a stewardship species, which is defined as those that are restricted to distinct geographical areas, but otherwise not currently at risk (Rich et al. 2004). However, Partners in Flight recommends that "stewardship" species merit special attention for conservation action within their core ranges (Rich et al. 2004), which would include eastern Arkansas. The 36.3% reproductive success of Mississippi Kites documented during this study was lower than other reported nest success estimates reported from other parts of its breeding range. Researchers elsewhere in the MAV have documented reproductive success rates of 61% in Illinois (Evans 1981) and 42% in Missouri (Barber et al. 1998). Studies throughout the West have documented success rates of nests ranging from 49–84% (Parker 1974, 1975, 1999, Glinski and Ohmart 1983, Shaw 1985, Gennaro 1988). The higher nest success in the western populations are probably because these kites are typically colonial nesters, which provide these birds a relatively effective predator deterrent (Lack 1968, Anderson and Hodum 1993). The birds breeding in Arkansas are solitary nesters.

The nest productivity in this study (1.0 young fledged per successful nest) was equivalent to that reported by Evans (1981) and Barber et al. (1998) in the MAV, but lower than reported for western populations 1.29–1.57 young/successful nest (Parker 1974, Glinski and Ohmart 1983, Shaw 1985, Gennaro 1988). Based on the lower productivity documented in the MAV, we suggest that these populations may lack the prey abundance to raise a brood successfully consisting of more than one nestling. Numerous studies on raptors and other bird species have documented a strong relationship between the availability of prey and reproductive success (e.g., Newton 1998, Macías-Duarte et al.

2004). Furthermore, the low brood size and video documentation of a nestling killing then eating its younger sibling also suggests that prey abundance may be a factor contributing to the relatively low productivity present in the WRNWR.

Reproductive success documented in the WRNWR may not be adequate to sustain a viable population. Review of the literature supports that the reproductive performance (1.0 fledgling produced for 36% of occupied nests) that we observed in the WRNWR is not satisfactory for a viable population of kites (e.g., Henny and Wight 1972, Martin et al. 1996). As a comparison, nest success estimates for other medium-sized woodland raptors in North America are as follows: 53–85% for Cooper's Hawks (Rosenfield and Bielefedt 1993), 50–80% for Broad-winged Hawks (Goodrich et al. 1996), and 53–88% for Red-shouldered Hawks (Crocoll 1994). All of these species produce more than 1 young per successful nest. The nesting success for Mississippi Kites in this study (36%) was more similar to that in other studies in the MAV, but the overall reproductive success in this study was still lower than those documented in Illinois (Evans 1981) and in Missouri (Barber et al. 1998). Using the reproductive data from our research and an estimated annual adult mortality of 5% and an annual juvenile mortality of 45% we ran a population viability analysis with the program Vortex analysis (Miller and Lacy 2005) to determine if the current reproductive conditions in the WRNWR were adequate to sustain a population. The Vortex analysis predicted that the model population would go extinct within 100 yr if there was no immigration of kites from other populations. This analysis suggests that the WRNWR Mississippi Kite population represents a "sink" population and may be dependent on immigration from other populations for its long-term maintenance.

Parker (1999) suggested that the larger population of humans in the East during the early 1900s may have had a greater negative influence on the kite population than it did in the less-populated western states. The large amount of deforestation and forest fragmentation that has gone on in the MAV may still be negatively affecting the current Mississippi Kite population trends as well as trends in other bird species. Rich et al. (2004) classified 67 bird species of continental importance, based on evaluation following Partners in Flight criteria, that are associated with wetland habitats in all or part of their range. Of these, 42 are listed as watch list species, which show some combination of population decline, small range, or distinct threats to habitat, and warrant special attention (Rich et al. 2004). The decline of wetland-associated raptors has not only been documented in the MAV. Martin (2004) documented a decline of 78% in nesting Red-shouldered Hawks in Maryland over a 32-yr study, and suggested that the decline was also a result of human activities such as logging and development of the surrounding area. In Arkansas, the increase of agriculture fields has replaced many of the natural wetlands and forest, and may adversely impact the kite population.

Numerous studies conducted on the effects of forest fragmentation have shown negative effects on the reproductive success of birds (e.g., Yahner and Scott 1988, Nour et al. 1993, Porneluzi et al. 1993, Bayne and Hobson 1997). Also numerous studies have documented the adverse affects of forest edges on avian nest success (e.g., Vander Haegen and DeGraff 1986, Bollinger and Peak 1995, Marini et al. 1995, Saracco and Collazo 1999, Batary and Baldi 2004). Edges can be created not only by agriculture, roads, and power line right-of-ways, but by natural configurations (e.g., waterways). Edges can serve as travel corridors for predators (Chasko and Gates 1986, Small and Hunter 1988, Gates and Giffen 1991), although the few studies that have examined predation rates at forest-water edges have mixed results. Saracco and Collazo (1999) documented lower predation rates on nests along interior and forest-river edges than along forest-farm edges, and Vander Haegen and DeGraff (1986) found artificial nests in riparian buffer strips were depredated more than those in located in intact riparian forest. In contrast, Bollinger and Peak (1995) found predation rates along forest-lake and forest-farm edges to be uniformly high. Bader (2007) found that Mississippi Kite nest sites were usually closer to an edge than locations selected at random. Nest predators, particularly snakes and birds are often more abundant along forest edges than in forest interiors (Marini et al. 1995, Saracco and Collazo 1999, Chalfoun et al. 2002). The selection of nesting sites near edges may be contributing to low nest success for Mississippi Kites in the WRNWR.

Our data from video cameras suggested that predators were the primary cause of Mississippi Kite nest destruction. Without cameras, the identification of predators that leave little or no evidence of their presence at nest sites, such as Barred Owls or rat snakes, would be difficult and unreliable. Mississippi Kites often nest in tops of superemergent trees, and thus are conspicuous. Nest placement and frequent vocalizations by the adults as they approach a nest may combine to make the nest obvious to aerial predators. Martin et al. (2000) found that nest predation increased with increased parental activity of passerines. They also documented that nest site location was a major factor influencing nest predation. Great Horned Owls (*Bubo virginianus*) are the most commonly reported predators of nestlings and nesting adult Mississippi Kites (Jackson 1945, Fitch 1963, Parker 1974, Evans 1981, Glinski and Ohmart 1983). Mammal predators including raccoons (*Procyon lotor*) and fox squirrels (*Sciurus niger*) prey on eggs, nestlings, and nesting adults (Sutton 1939, Allan 1947, Parker 1974). Red-tailed Hawks (Miller 2005) have also been reported as predators of kite eggs and nestlings (Parker 1999). To our knowledge, depredation on kite nests by Barred Owls and western rat snakes had not been documented prior to our study.

Siblicide often followed by cannibalism has been recorded for many raptors (e.g., Ingram 1959, Pilz and Siebert 1978, Poole 1982, Bortolotti et al. 1991). Poole (1982) found that brood reduction at Osprey (*Pandion haliaetus*) nests coincided with reduced food delivery rates in food-stressed colonies. Bortolotti et al. (1991) reported that cannibalisms in American Kestrel (*Falco sparverius*) nests were more common in territories with lower prey densities.

The nesting of kites and other birds in the WRNWR coincides with frequent spring flooding in bottomland hardwood forest. An inundated forest floor could drive predatory rat snakes into the arboreal habitat. Construction of levees along the eastern and southwestern margins of the refuge in the late 1930s has restricted the natural flood regime during high flow periods, increasing the depth of the flood waters. Low food levels and arboreal activity by rat snakes appear to contribute significantly to low Mississippi Kite reproductive success at the White River National Wildlife Refuge and that both phenomena could be related to recent changes in hydrology.

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